EINDHOVEN UNIVERSITY OF TECHNOLOGY

Communication Theory (5ETB0)
Module 10.1

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Module 10.1

Presentation Outline

Problem Description: Serial Transmission

Motivation

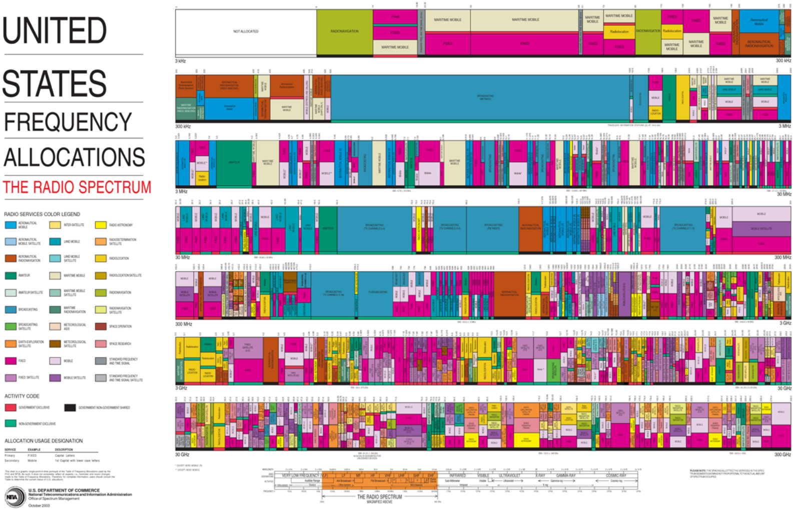
- A channel with a bandwidth of W Hz can accommodate roughly $2WT$ dimensions each T seconds (dimensionality theorem)
- Obtained for building-block waveforms that are zero outside $[0, T]$
- Can we get $2WT$ extra dimensions every new T seconds ($2W$ extra dimensions per second)?
  - Answer is yes, using building-blocks waveforms with nonfinite duration

Consequences

- Building blocks that are not time-limited:
  - Finite bandwidth, but
  - inter-symbol interference is created

In this module we will show that time-shifted versions of the original pulse can be used, and that some properties of the pulse make the interference disappear (with the right receiver).

Motivation: Who Cares about the Spectrum?



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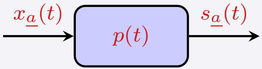
Presentation Outline

A Question Before Getting Started...

A linear filter fed with a train of impulses

- Suppose we have a linear filter
- Impulse response $p(t)$ and fed with a train of weighted impulses

$$x_{\underline{a}}(t) = \sum_{k=0}^{K-1} a_k \delta(t - kT)$$



where $\underline{a} = (a_0, a_1, \ldots, a_{K-1})$

- What is the output of the filter $s_{\underline{a}}(t)$?

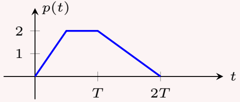
Answer:

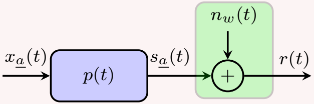
$$s_{\underline{a}}(t) = \sum_{k=0}^{K-1} a_k p(t - kT)$$

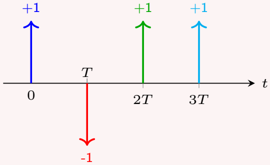
Model: Binary PAM

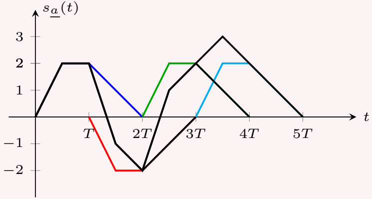
Serial pulse-amplitude modulation (PAM)

Transmitted signal is: $s_{\underline{a}}(t) = \sum_{k=0}^{K-1} a_k p(t-kT)$. Vector of amplitudes $\underline{a} = (a_0, a_1, \ldots, a_{K-1})$ consists of symbols $a_k, k = 0, \ldots, K-1$ taking values in the alphabet $\mathcal{A} = \{-1, +1\}$





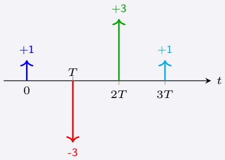


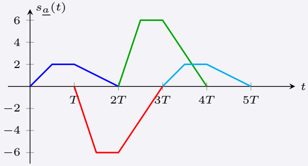


Model: Nonbinary PAM

Non-binary PAM Example

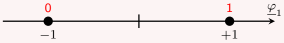
To double the transmission rate, we can double the number of bits per symbol. This can be obtained using an alphabet with 4 messages: $\mathcal{A} = \{-3, -1, 1, 3\}$.

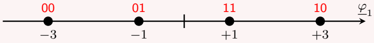




Two Comments

- Serial PAM is similar to bit-by-bit signaling with $K = 1$. Differences: not using time-limited pulses and nonbinary alphabets $\mathcal{A}$.
- Geometrical representations of binary and nonbinary PAM are:





Summary Module 10.1

Take Home Messages

- Pulses that are not time-limited can be used for transmission
- Serial pulse amplitude modulation (binary and nonbinary)
- Inter-symbol interference is generated

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